इंटरनेट मानक

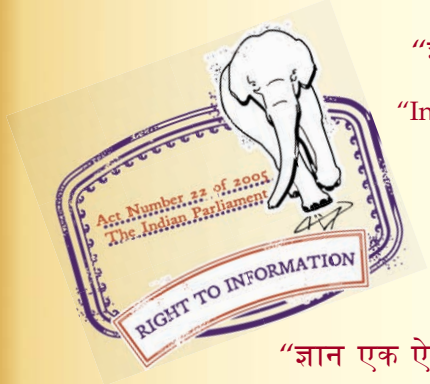
Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 4651-5 (1980): Code of practice for planning and design of ports and harbours, Part 5: Layout and functional requirements [CED 47: Ports and Harbours]



"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

IS : 4651 (Part V) - 1980
(Reaffirmed 2012)

Indian Standard

CODE OF PRACTICE FOR PLANNING AND DESIGN OF PORTS AND HARBOURS

PART V LAYOUT AND FUNCTIONAL REQUIREMENTS

(First Reprint AUGUST 1996)

UDC 627.2 : 624.04 : 006.76

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 8 *November* 1980

Indian Standard

CODE OF PRACTICE FOR PLANNING AND DESIGN OF PORTS AND HARBOURS

PART V LAYOUT AND FUNCTIONAL REQUIREMENTS

Ports and Harbours Sectional Committee, BDC 66

Chairman	*Representing*
BRIG O. P. NARULA	Ministry of Shipping and Transport
Members	
CAPT P. BALARAM	Marine Department, Madras Port Trust, Madras
CAPT G. A. MANDE (*Alternate*)	
SHRI M. BALASUBRAMANIAM	Mormugao Port Trust, Vasco De Gama (Goa)
SHRI U. R. BALASUBRAMANIAM	Engineering Department, Madras Port Trust, Madras
SHRI N. VARDARAJAN (*Alternate*)	
CAPT P. N. BATRA	Marine Department, Calcutta Port Trust, Calcutta
CAPT D. K. DUTTA (*Alternate*)	
SHRI N. P. BHAKTA	Pre-Investment Survey of Fishing Habour, Bangalore
SHRI H. V. RAMASWAMY (*Alternate*)	
SHRI R. K. BUDHBHATTI	Public Works Department, Government of Gujarat, Ahmadabad
SHRI B. P. KUKADIA (*Alternate*)	
CHIEF ENGINEER	Chief Engineers Department, Calcutta Port Trust, Calcutta
CHIEF PORT OFFICER	Maharashtra State Port Authority, Bombay
COASTAL ENGINEER (*Alternate*)	
REAR ADM A. G. DASTIDAR	Indian Navy, Vishakhapatnam
LT-COL V. S. BHANDARI (*Alternate*)	
DIRECTOR	Central Water and Power Research Station, Pune
CHIEF RESEARCH OFFICER I (*Alternate*)	
SHRI A. H. DIVANJI	Asia Foundation & Construction Pvt Ltd, Bombay
SHRI A. N. JANGLE (*Alternate*)	
SHRI K. K. FRAMJI	Consulting Engineering Services India Pvt Ltd, New Delhi
SHRI S. GHOSH (*Alternate*)	
SHRI S. R. GAITONDE	Bombay Port Trust, Bombay

(*Continued on page* 2)

(*Continued from page* 1)

Members	*Representing*
SHRI HASMUKH P. OZA	In personal capacity (*Atul, 20 Pathik Society, Ahmadabad 13*)
SHRI P. S. RAO JANAMANCHI	Oil and Natural Gas Commission, Bombay
SHRI R. D. KOHLI	Shipping Corporation of India, Bombay
SHRI MANOHAR SINGH	Continental Construction Pvt Ltd, New Delhi
SHRI J. P. AWASTHI (*Alternate*)	
CAPT M. V. K. MENON	Cochin Port Trust, Cochin
SHRI M. K. MATHEW (*Alternate*)	
DR S. K. NAG	Hydraulic Study Department, Calcutta Port Trust, Calcutta
DR A. N. BISWAS (*Alternate*)	
SHRI H. NANDI	Project & Equipment Corporation of India Ltd, New Delhi
PROF S. NARASIMHAN	Indian Institute of Technology, Bombay
DR I. V. NAYAK	Karnataka Regional Engineering College, Suratkal, Srinivasnagar
PROF G. RANGANNA (*Alternate*)	
BRIG OMBIR SINGH	Engineer-in-Chief's Branch, Army Headquarters
SHRI B. K. PANTHAKY	Hindustan Construction Co Ltd, Bombay
SHRI P. V. NAIK (*Alternate*)	
SHRI G. S. RAMAIAH	Andaman Lakshadeep Harbours Works, New Delhi
SHRI T. V. RAMANA RAO	Vishakhapatnam Port Trust, Vishakhapatnam
SHRI P. S. RAO (*Alternate*)	
SHRI S. R. ROESSLER	Howe (India) Pvt Ltd, New Delhi
SHRI C. S. DEBKE (*Alternate*)	
CAPT SUBIMAL MOOKERJEE	India Navy (Operational)
CDR P. S. SIVAMANI (*Alternate*)	
SUPERINTENDING ENGINEER (CENTRAL MECHANICAL CIRCLE)	Public Works Department, Government of Tamil Nadu, Madras
SENIOR DEPUTY CHIEF ENGINEER (BLDGS) (*Alternate*)	
SHRI M. C. TANDON	Stup (India) Ltd, Bombay
SHRI M. K. CHATTERJEE (*Alternate*)	
DR V. D. TAPASVI	Engineers India Ltd, New Delhi
SHRI M. CHOWDHURY (*Alternate*)	
SHRI D. AJITHA SIMHA, Director (Civ Engg)	Director General, ISI (*Ex-officio Member*)

Secretary

SHRI K. M. MATHUR

Deputy Director (Civ Engg), ISI

Indian Standard

CODE OF PRACTICE FOR PLANNING AND DESIGN OF PORTS AND HARBOURS

PART V LAYOUT AND FUNCTIONAL REQUIREMENTS

0. FOREWORD

0.1 This Indian Standard (Part V) was adopted by the Indian Standards Institution on 8 February 1980, after the draft finalized by the Ports and Harbours Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 A great need has been felt for formulating Indian Standards relating to various aspects of water front structures. These Indian Standards IS : 4651 pertaining to planning and design of ports and harbours structures are being formulated in various parts. Part I of the standard covers site investigation, Part II earth pressures, Part III loading and Part IV general design considerations. This part cover layout and functional requirements.

0.3 This standard outlines some of the desirable technical characteristics of ideal ports and harbours and is intended to provide some guidelines to the planners and designers who may be required to select a specific site, within the general locality specified, and develop a new or an existing port and harbour.

0.4 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

---

1. SCOPE

1.1 This standard (Part V) lays down functional requirements for the planning and developing of commercial ports and harbours and gives a general

*Rules for rounding off numerical values (*revised*).

recommendation for the layout of the following harbour and operational facilities:

a) Navigation channel,
b) Harbour basin,
c) Piers and wharves,
d) Storage areas and sheds and storage of hazardous/obnoxious cargo,
e) Open storage area,
f) Other functional and operational buildings,
g) Roads and port railways, and
h) fire protection measures.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 7314-1974* shall apply.

3. SELECTION OF HARBOUR SITE

3.0 For selection of site of ports and harbours the following factors need consideration.

3.1 Access — Direct access with existing means of internal communications and dispersion such as rivers, highways, canals and railways is desirable. Where topography at sites contiguous to inland communication is not favourable, cost of providing connection to such facilities should be balanced against savings in the cost of developing remote sites.

3.2 Size and Depth — Adequate size of area and sea front, inshore of breakwaters, if any, and depth without excessive dredging should be available to accommodate expected traffic. There should be room for future expansion.

3.3 Physical and Topographical Features

3.3.1 *Sheltering from Winds and Ocean Waves* — Natural sheltering features such as headlands, off-shore shoals and bars, would reduce the artificial sheltering requirements, such as breakwaters, and thereby reduce cost. Headlands offer protection from winds and waves.

3.3.2 *Subsoil Conditions* — Sites should be suitable for the construction of port structures and development of water area. Availability of rock at shallow depths may be good for structures but unworkable for water area to be dredged or used as anchorage. Very soft bottom does not also provide good holding conditions for anchors. Clay or other firm tenacious materials

*Glossary of terms relating to port and harbour engineering.

would form better holding ground for anchorage. Characteristics of soil/ rock at design depth level would thus influence the choice of the harbour site.

3.3.3 *Dredging*— Minimum capital and maintenance dredging and freedom from dredging large quantities of rock or other hard bottoms should be an important consideration.

3.3.4 *Shore Line Stability* — Non-eroding shore lines should be preferred. Land adjacent to shore line should gradually slope away from the beach. Locations with pronounced topographical relief such as cliffs adjacent to shore line may create problems.

3.3.5 *Upland Drainage* — Upland areas should be naturally well drained and there should not be health hazards due to local drainage conditions

3.4 Hydrographic and Hydrological Factors

3.4.1 *Tides* — Locations with tidal bore and high tidal range should be avoided.

3.4.2 *Current Velocity* — Current velocity should preferably not exceed 4 knots (7·4 km/h) anywhere within the harbour.

3.5 Meteorological Factors — Locations subject to pronounced, severe and frequent storms should be avoided.

3.6 Construction Materials, etc — Availability of construction material, particularly rock for breakwater and other construction works and adequate fresh water supply will be an advantage and will reduce cost.

3.7 Strategic and Security Conditions — Strategic and security conditions at a particular site shall be given due consideration.

4. NAVIGATION CHANNEL

4.0 General — Water ways should be laid out in proper configuration and designed for good control and safe manoeuvrability of ships under all conditions, winds, currents, waves, visibility and in adverse weather conditions. It is difficult to lay down rigid standards on various aspects of navigation channel, as conditions will vary from port to port depending upon its location, natural shelter, tidal and other condition, prevailing depths and various other factors. Strong currents and winds, for example, have a very significant effect on the alignment, width, depth, turning circles, etc, of the proposed channel and can alter the requirements appreciably. The local conditions and the port's own knowledge and experience are very important factors.

4.1 The use of channel for navigation pre-supposes that the channel is adequately marked and lit for night navigation and is provided with necessary lighted transits and modern navigational aids.

4.2 Alignment — The alignment of channels should be such that ships expected to use the channel can navigate with reasonable safety under adverse conditions of tide, current, wave and wind action. The following are general conditions in determining the optimum channel alignment. The channel should be straight as far as possible.

4.2.1 The channel should be located in areas of maximum natural depth to reduce cost of initial and maintenance dredging.

4.2.2 As far as possible, areas prone to excessive siltation and littoral drift should be avoided.

4.2.3 The number of curves and the angles of deflection of the axis (*see* **4.4**) should be kept down to a minimum.

4.2.4 As far as practicable, a minimum angle between the channel axis and the resultant effect of the direction of the prevailing wind and swell and current should be maintained.

4.2.5 Adequate stopping distance (*see* **4.5**) to bring a vessel to a stop with or without tug, having regards to the requirements of the using agency and experience of the port authorities to handle vessel of a particular size should be provided.

4.2.6 The entrance to the basin should be located on the lee side of the harbour, where possible. If, however, the entrance has to be located on the windward size of the harbour, it should be adequately protected by breakwater.

4.2.7 In critical locations, for example, entrance to harbours, under bridges, approaches to docks, etc, straight approaches long enough for the vessel to become properly aligned to the berth is necessary.

4.3 Types of Channels

4.3.1 *Unrestricted Channels* — An unrestricted channel is a channel of sufficient depth and which has a width more than 10 times the beam of the largest ship likely to navigate the channel at all states of the tide.

4.3.2 *Semi-restricted Channels* — Semi-restricted channels are channels in shallow water where a certain amount of trenching is done by dredging, allowing for side slopes with the adjoining areas having less depth than in channel (*see* Fig. 1).

4.3.3 *Fully Restricted Channels* — Fully restricted channels are channels which are fully banked and where the entire cross-sectional area of the channel is generally dredged; for example in canals (*see* Fig. 2).

4.4 Curves and Bends — Curves, particularly sharp turns, should be avoided. Where these are necessary, the following requirements should be fulfilled as far as possible.

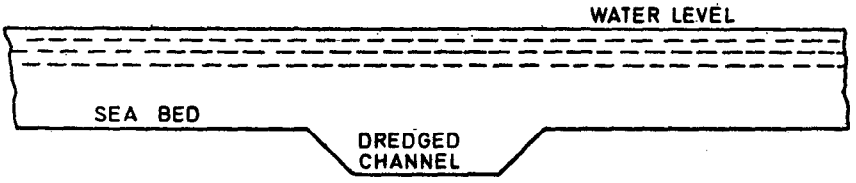


FIG. 1 SEMI-RESTRICTED CHANNEL

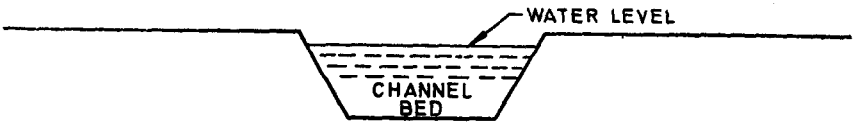


FIG. 2 FULLY-RESTRICTED CHANNEL

4.4.1 For vessels proceeding without tug assistance, the minimum radius, of the curve should not be less than 3 L for central angle of the turn up to 25°, 5 L for turns beyond 25°, and 10 L for turns beyond 35° where L is the length of the largest vessel. Where it is not possible to provide these radii the channel should be suitably widened. As a guide following radius of curvature is desirable, where possible.

R_{min} = 1 200 m for ship less than 150 m long O/A

= 2 000 m for 150 m long O/A

= 2 000 to 3 000 m larger than 150 m but smaller than 210 m long O/A

4.5 Stopping Distance — The stopping distance in channel varies with the displacement/horse power ratio, reverse power, shape of hull of the vessel, etc. As a rough guide, the following distance may be provided which should be sufficient for the vessel entering the harbour to reduce the speed and bring it to a complete halt.

Vessel in loaded condition	—	7 to 8 times the ship's length
Vessel in ballast	—	3 to 5 times the ship's length

In harbours where the entrance is exposed to weather, the stopping distances should be reckoned from the beginning of the protection work to the centre of the turning basin. The degree of protection required for the dredged channel will depend on the sea conditions prevailing in a particular location.

4.6 Depth — The following factors should be taken into account in designing the depth of the channel:

a) Size, draft, shape and speed of hull of the design vessel;

b) Trim of vessel when moving through water (termed drag);

c) Current velocity in the channel;

d) Squat assessed on the ratio between cross-sectional area of the immersed portion of the ship and cross-sectional area of the channel at low water;

e) Whether the channel is fully restricted, semi-restricted or unrestricted;

f) Number of lanes in channels;

g) Wind and wave action;

h) The tidal variation;

j) Dredging pattern and frequency;

k) Salinity and bottom material;

m) Degree of accuracies in hydrographic survey and other accuracies; and

n) Net under keel clearance.

4.6.1 Taking in consideration of the above factors, it is recommended that minimum under keel clearances should not be less than 10 percent of the draft of the vessel in the channel, 15 percent at the turning circle and 20 percent at entrance to the channel in unsheltered areas.

4.7 Width of Channel

4.7.1 The clear width of a restricted channel measured at the bottom of the dredged bed may be taken as the sum of the following three zones (*see* Fig. 3):

a) Manoeuvring lane (single lane) should be 180 to 200 percent of the vessel's beam in straight channels and suitably widened in curved channels;

b) *Bank Clearance* — Normally 75 to 150 percent of the beam of the largest vessel on each side; and

c) *Passing Clearance* — The distance between adjacent manoeuvring lane in two lane channel, should not be less than the beam of the largest vessel.

4.7.2 Where the width of the channel is to be reduced at the harbour entrance for obtaining tranquility conditions, the reduced width between pier heads shall be a minimum of 0·7 to 1 times the length of the largest designed vessel. Where the entrance is between sloping breakwaters the width should be measured at the maximum draft at mean low water.

4.7.3 Should currents or cross winds across the channel be experienced, the width of the manouvering lane should be increased on the basis of the direction and the maximum velocity of cross currents or wind experienced. An example of this allowance is given in Fig. 4.

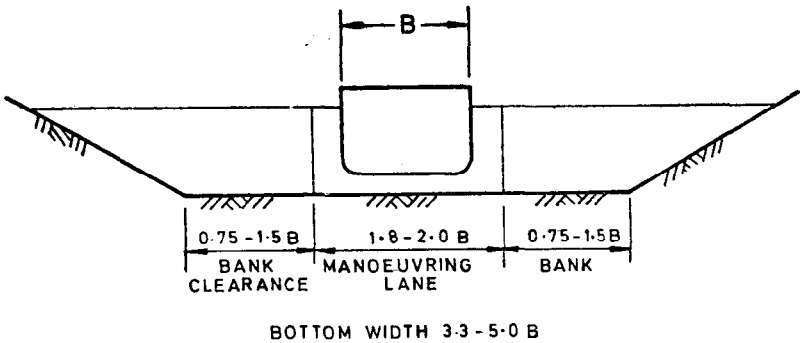


FIG. 3 WIDTH OF CHANNEL

4.7.4 In channels where ship yaw is experienced due to quartering seas, the width of the manoeuvring lane should be suitably increased.

4.7.5 In case of riverine ports having a very long channel with no intermediate anchorage and where navigation is dependent on tides, the width of the channel may have to be increased at places to allow for the vessel to swing round.

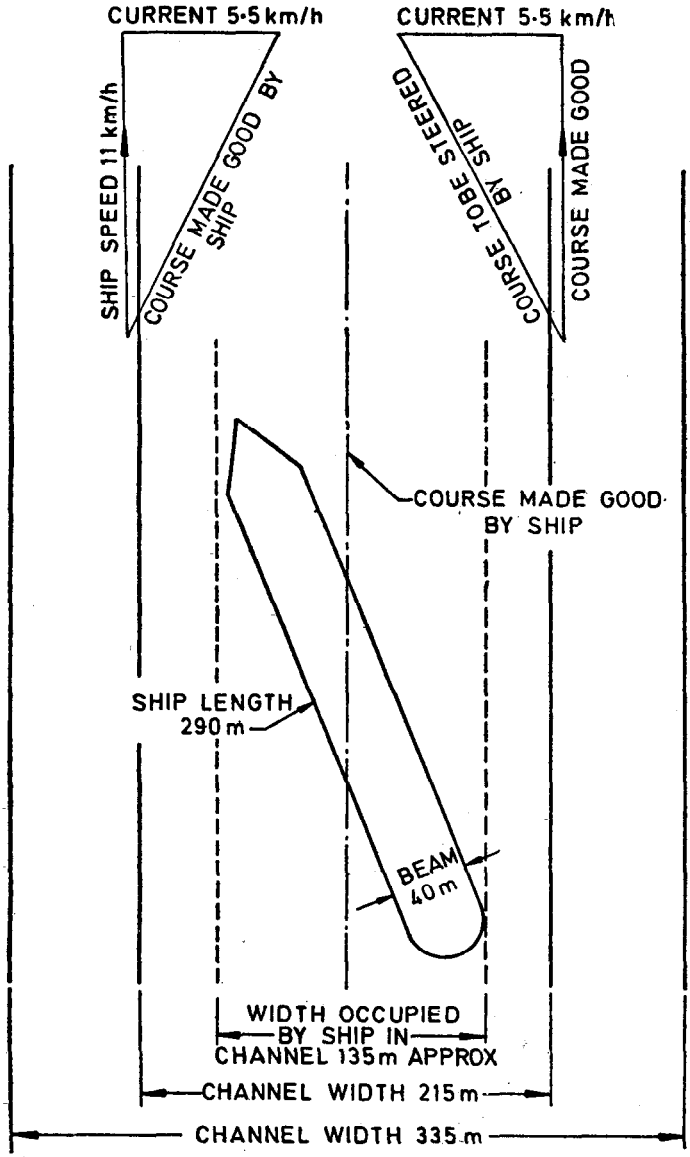


FIG. 4 EXAMPLE SHOWING ALLOWANCE DUE TO CURRENTS OR CROSS WIND

4.7.6 In increasing the width of the channel at curvature the widening of the curve should be done by the parallel bank method. The slope of the transition should be at least 1 in 20 (*see* Fig. 5).

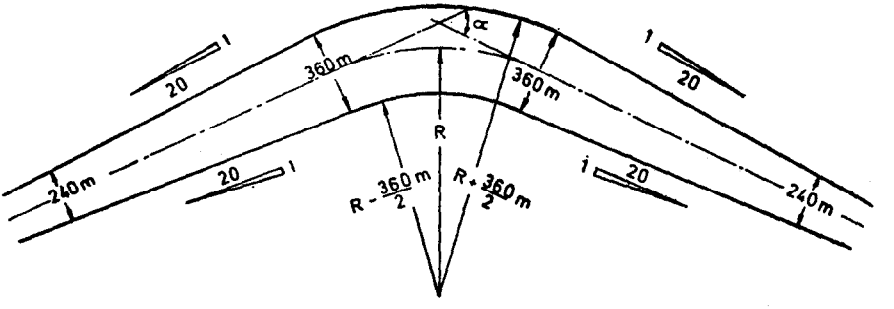


FIG. 5 PARALLEL WIDENED BEND IN CHANNEL

4.8 Currents and Winds

4.8.1 The current in channel section at harbour entrance should not be too strong or too sluggish to maintain required sediment movement. In general the maximum current should not exceed 4 knots (7·408 km/h) where possible. Where the current velocity exceeds this value, it may be necessary to adjust the channel cross section to maintain an optimum flow.

5. HARBOUR BASIN

5.1 Layout — The following are general considerations in determining the layout of a harbour basin.

5.1.1 Harbours receiving wide range of vessels should preferably be divided into at last two zones — one for larger ships, and the other for smaller crafts to be located in the inner and shallower regions of the basin.

5.1.2 A separate basin on the leeside of the main basin for bulk cargo and cargoes of noxious nature should be provided. Hazardous cargo wharves should be located keeping in view safety distances and clearance from other berths and installations preferably towards the outer end of the harbour or basin. Berths for vessels carrying explosives or petroleum lubricant (POL) products shall be located in isolated anchorage or areas keeping in view the safety distances. In all cases statutory requirements should be complied with.

5.1.3 The dimensions and layout of the basin should be critically examined with respect to short and long period resonance.

5.1.4 The berths and berthing basins should be located in areas which are best protected from wind and wave disturbance and away from the disturbance incident upon the harbour entrance and resonance.

5.1.5 The turning basin should be located at the head of navigation channel and should occupy the central area of the main basin offshore of the berths.

5.1.6 The anchorage area should be located close to the harbour entrance but well clear off the channel traffic.

5.1.7 Offshore moorings should be located as close as possible to the shore.

5.1.8 A spending beach should be provided, where necessary, opposite harbour entrance.

5.2 Depth — The depth of the harbour basin below the chart datum should be determined based upon tranquility and salinity conditions. The minimum depth of water within the harbour basin should not be less than the loaded draught of the largest vessel plus an allowance of 0·60 to 0·75 m for underkeel clearance. Where the harbour bottom is hard, the allowance should be increased to 1 m. Additional clearance may be required in basins where wave energy disturbances exist.

5.3 Water Area — The total water area requirement for the harbour basin would normally comprise of the following:

a) Berthing area,

b) Passage and manoeuvring area,

c) Turning basin/circle, and

d) Anchorages and offshore moorings.

Separate water areas should be allowed for channels, special berths, and spoil grounds if disposal of dredging should be done. The capacity of the water areas within the harbour may be evaluated in terms of numbers, types and sizes of vessels which could be simultaneously anchored within the harbour limits and at pier or wharf berths. Unless the harbour is a natural one, because of economic reason, its size should be kept as small as possible as will permit safe operations to take place.

5.3.1 *Berthing Area* — The space required for berthing of ships should be based on the dimensions of the largest design ship and the number and type of ships using the harbour. This is the area in front of the berthing structure required to accommodate the vessel or vessels and attendant craft.

5.3.1.1 *Length of berthing area* — For long continuous wharf for large ocean giving vessels, the recommended length of the berthing area should not be less than the length of the design vessel plus 10 percent subject to a minimum of 15 m. This may be increased up to 20 percent in basin exposed to strong winds and tidal conditions. For finger piers and marginal quays meant for general cargo vessel provisions are given in **6.3.1 to 6.3.3.**

5.3.1.2 *Width of berthing area* — The width of berthing area should not be less than 1·15 times the beam of the design vessel. To this width the beam or beams of the attendant craft should be added.

For accommodating several vessels abreast, the width of the berthing area should equal the number of vessels for berth multiplied by 1·10 times the beam of the design vessel.

For finger pier, the width of the slip including manoeuvring area (*see* **5.3.2**), that is, the water area between adjacent piers should be not less than 3 times the beam of the design vessel plus 30 m for single berth piers and 4 times the beam of the design vessel plus 45 m for double berth piers. An extra allowance should be made in cases where the wind velocity is likely to exceed No. 5 in the Beaufort scale that is a wind velocity of 35 km/h.

5.3.2 *Passage and Manoeuvring Area* — This is the space beyond the berthing area required for the passage of vessels and tugs, and to permit vessels to enter or leave their berths.

5.3.2.1 The width required to permit a vessel to swing freely into a berth is 2·0 times the length of the vessel for berths at 90°, 1·50 times for berths at 45° and, 0·60 times the length of the vessel for berthing parallel to the fairway.

5.3.3 *Turning Basin/Circle* — The size and/or diameter of the turning basin would depend on the geometry of water area available and berth arrangement and shall be as follows.

5.3.3.1 The diameter of the turning circle where vessels may be warped round turning dolphins, should be minimum 1·2 times the length of the largest vessel to be turned.

5.3.3.2 Where vessels turn by free interplay of the propeller and rudder assisted by tugs, the minimum diameter of the turning circle should be 1·70 to 2·0 times (1·70 for protected locations and 2·0 for exposed locations) the length of the largest vessel to be turned. Where no tug assistance is available, the diameter of the turning basin may be as large as 4 times the length of design ship.

5.3.4 *Anchorages and Offshore Moorings* — The water area required for anchorages and mooring basin depend on number, type and sizes of vessels which would require protection in bad weather and/or the number, type of buoy mooring berths required for supplementing bulk cargo handling.

5.3.4.1 For free swinging moorings (*see* Fig. 6), the radius (R) in metres of the anchorage area per berth may be computed from the following equation:

a) *Using ships anchor and chain*

$$R = 165^* + L + \tfrac{1}{2} L$$

where L is the overall length of the vessel in metres.

b) *Using mooring buoy*

$$R = 1{\cdot}2\, L + r$$

where r = radius of swing of buoy allowing for tidal range in metres, and may be estimated from standard catenary equation.

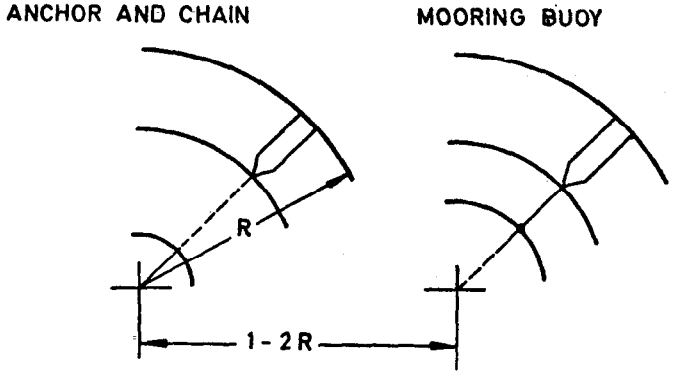


FIG. 6 FREE SWINGING MOORINGS

5.3.4.2 *For bow and stern mooring* — The water area per berth may be calculated on the following basis (*see* Fig. 7):

a) For anchor/buoy system, the length (X) in metres, and width (W) in metres, of the anchorage area

$$X = 1{\cdot}2\, L + r + 110^*$$

$$W = 2r + B$$

where

L = length of vessel in metres,

r = radius of swing of the buoy in metres, and

B = the beam of the vessel in metres.

*Equivalent to 4 shackles.

b) For two-buoy system:

$X = 1{\cdot}4\ L + 2r$

$W = 2r + B$

c) For anchors/dolphin system:

$X = 1{\cdot}2\ L + 110$*

$W = 2B$

d) For two-dolphin system:

$X = 1{\cdot}4\ L$

$W = 2B$

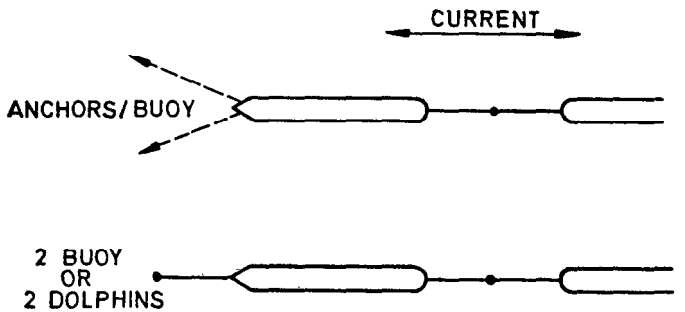


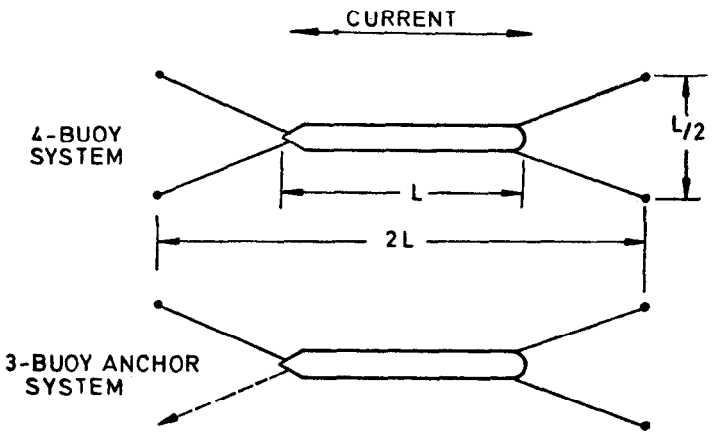
FIG. 7 BOW AND STERN MOORINGS

5.3.4.3 In multiple point moorings, the vessel is secured to a minimum of four mooring points thereby restraining the vessel to a more or less fixed position. Typical mooring arrangements and area requirements are shown in Fig. 8. The selection of the mooring system should be based on the degree of exposure, size of vessel, degree of restraint required and bottom material.

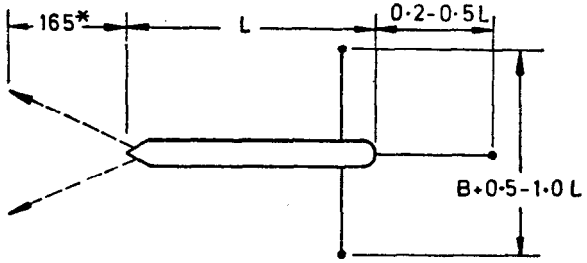
A symmetrical layout of buoys about the centre line of the berth would be an advantage where currents and wind directions reverse frequently.

5.4 Sheltering from Wind, Currents and Waves — The harbour basin should be designed and planned in such a way that an acceptable degree of shelter can be provided to vessels entering or leaving the berths or basin against wind, currents and waves disturbances.

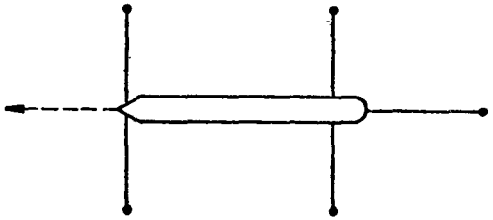
*Equivalent to 4 shackles.



4-POINT MOORING SYSTEM



5-POINT MOORING SYSTEM



6-POINT MOORING SYSTEM

*Equivalent to 6 shackles, that is 165 m.

FIG. 8 MULTIPLE POINT MOORINGS

5.4.1 *Waves* — As a general rule the wave disturbance within the harbour should not exceed the following tranquility condition:

	Maximum Significant Wave Height in m		
	At berth	Turning basin	Offshore mooring
General cargo	0·65	0·90	1·50
Bulk cargo	0·90	1·20	1·50 for berthing 2·50 for operation
Container cargo	0·65	1·20	—
Passenger vessel	0·65	—	—
Trawler and fishing boats	0·60-0·90	—	—
Deep sea tugs	—	1·20	—
Dredgers	—	0·45-2·00	—
Supervisor's boats	0·60	0·60-1·20	—

The actual figures will depend on the mooring and berthing systems, the methods of loading and unloading used at a particular berth, and with the orientation of the berth in respect of wave directions.

5.4.2 For studying the problem of shelter within the harbour basin and for designing appropriate protective measures with precision, hydraulic models should be resorted to. Models for this type of study should be designed in accordance with the scale relations based on Froude Law. The use of hydraulic models should be combined with marine ship experience and good engineering practice for proper results.

5.5 Harbour Entrance

5.5.1 *Width* — The width of harbour entrance should be minimum consistent with safe navigation and tranquility requirements on the harbour and as a rough guide may be considered as follows:

For medium vessels (that is, vessels up to 150 m overall length) — 100 to 150 m, and

For large vessels — 200 to 250 m (*see also* 4.7.2).

Where the entrance is between sloping breakwaters, the width should be measured for the maximum draft of the largest vessel at bed level.

5.5.2 *Location* — The entrance should be on leeward side of the harbour where possible. If, however, the entrance must be located on the windward end of the harbour, adequate overlap of the breakwater should be

provided so that the vessel should have passed through the restricted entrance and be free to turn.

5.5.3 The effect of cross winds and/or currents should be carefully considered.

6. PIERS AND WHARVES

6.1 Required Features — The general features, convenience and facilities of piers and wharves complex should be as follows:

a) Berths of sufficient depths and widths to allow vessels to approach and leave easily and move safely;

b) Adequate fender system;

c) Sufficient mooring devices, bollards, etc, to safely secure vessel;

d) Cargo handling equipment;

e) Covered and open storage spaces for cargoes, office space and other operational requirements;

f) Proper board and rail accesses, adequate facilities for loading/unloading road vehicles and rail wagons and parking spaces for lorries and other road vehicles;

g) Passenger traffic conveniences, waiting rooms, baggage rooms, immigration facilities, customs inspection; and

h) Availability of suitable utility services, fire fighting equipment and alarm system.

6.2 Location and Form — The location and form for berths should be decided by the following general consideration:

a) Maximum ease of entering and leaving berth,

b) Availability of required quayage for the design vessel,

c) Freedom from harbour line restrictions,

d) Foundation condition to permit economic design, and

e) Isolation requirements and safety regulations.

Special berths, such as, for noxious cargoes, tankers or explosive berths, safety regulations should be given extra consideration.

6.2.1 *General Cargo Berths* — These berths require a proper apron with cargo handling cranes, rail sidings, circulatory roads, a large shed, adequate open storage areas, proper road and rail accesses, loading/unloading areas, lorry parking space, etc. The activities at a general cargo berth generate a good deal of traffic. These berths should, therefore, be kept clear off the arterial roads but in close proximity to in/out gates.

6.2.2 *Passenger Berths* — These should be located in close proximity to public road and if possible, rail systems to avoid interference of passenger traffic with dock traffic and security requirements. The berth should preferably be located outside the impounded dock and should have adequate area for a passenger terminal building, circulatory roads, parking of vehicles and railway platform, if possible. The berth should be located as far away as possible from bulk handling berths, tanker berths, and explosive berths.

6.2.3 *Bulk Handling Berths* — These berths require very large storage areas for import/export cargo, storage silos, and good road and rail service behind to berth. Otherwise means should be provided for carrying materials to and from stockpile and the berth. These berths normally generate a large amount of dust due to which they should be kept in remote areas away from passenger and general cargo berths and so located that the wind may carry the dust away from such berths.

6.2.4 *Container Berths* — These berths require fairly large level and well paved back-up areas over 8 hectares immediately behind the berth. For safety of operation the berth should preferably be fenced off with restricted entry/exit gates. Where containers are railborne, rail sidings should be laid immediately behind the storage areas. Good road accesses shall be provided. As the container operation is based on high rates of loading/unloading and a quick turn round time for the vessel such berths should preferably be located outside impounded docks. If inside the basin the berth should have easy access for approach and leaving.

6.2.5 *Tanker Berths* — As the nature of cargo handled at such berths is explosive such berths should be located in remote areas of the harbour where adequate depth of water, turning area, waiting and emergency anchorages and adequate land for storage of products is available in the vicinity. If inside a basin the tanker berth should be along side the outer arm at least 90 m away from the nearest berth and from the edge of the turning basin. Tanker berths should also be so located that wind may carry away spillage from the edge of the turning basin. Tanker berths should also be so located that wind may carry away spillage from general anchorage or berthing areas.

6.2.6 *Explosive Berths* — These should not normally be located in general port area. For safety and distance requirements local and/or international regulations should be applicable.

6.2.7 *Ship Repair Berths* — These berths should be located where good workshop and road access are available. These berths do not require very wide aprons.

6.2.8 *Lay-Up Berths* — These berths are required for tying up port and commercial flotilla when idle. Their requirement is, therefore, adequate

quay and water area not far away from the commercial part of the dock. Water and oil bunkers should preferably be supplied at this berth.

6.2.9 *Hazardous Berths* — These should be isolated from passenger berths and requirements as specified in relevant regulations should be followed.

6.3 Dimensions — The size of the pier and wharf should be decided on the basis of dimension of the largest vessel it is required to handle, the quayage area required for transit shed, number of railway tracks, truck lanes, use of crane and the width of apron required to accommodate mooring facilities, and utility services. As a rough guide the dimensions given in Fig. 9 should apply to general cargo berths. The design of a bulk handling berth or container berth requires special consideration and is governed by the type of mechanical handling equipment to be used as well as the vessel sizes. The design of such berths should be co-ordinated with the design of the equipment to be used. As a rough guide, the depth of water at berth and length of berth may be taken from Appendix A.

6.3.1 *Finger Piers for General Cargo* — The size of the pier is determined on the basis of the largest vessel it is required to handle, the area required for apron, transit sheds, railway tracks, roads and other utility services. In this connection reference may be made to **5.3.1.1**. For initial planning, the dimensions given in Fig. 9 Types I, IIA and IIB may be employed. The area of the transit shed may be taken as given in **7.2.1.1** where L is the length of the berth in metres.

6.3.2 *Marginal Quays for General Cargo* — The layout of berths is based on consideration similar to those for finger pier berths as above. The layout of a good general cargo berth is shown in Fig. 9 Type III.

6.3.3 The length of pier or wharf meant for a single vessel should be 50 to 60 m more than the overall length of the design ship. Where more than one vessel has to be accommodated, recommendations made under **5.3.1.1** shall govern.

6.3.4 The minimum width of the pier should be calculated on the basis of area required for transit shed, number of railway tracks, truck lanes of minimum width, apron and width of crane track. As a rough guide an area of 8 500 m^2 may be allowed for transit shed for each berth.

6.3.5 *Width of Apron* — The minimum width of apron may be taken as follows:

Facilities	*Apron width* m
a) For general cargo:	
One way traffic	6·50
Two way traffic	8·00
One track + One truck	9·50

One track + gantry crane	11·00
Two tracks + one truck	13·50
Two tracks + one gantry crane	15·00
Modern cargo berths	15·00 to 18·00
b) For fish wharf	3·00
c) Container berth	40·00
d) Bulk handling and other specialised berths	Determined by the travelling cargo transfer equipment, conveyor, access road and railways, etc.
e) Tanker berth	Determined by the liquid transfer equipment, pipelines, etc.

6.3.6 *Width of Pier* — The width of a pier handling bulk cargo such as ore, grain, cement, etc, should be sufficient to accommodate the travelling cargo transfer equipment, conveyor and access road.

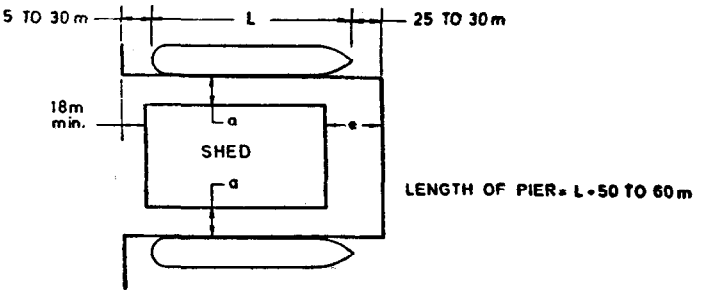
6.3.7 *Deck Elevation* — The required deck elevation of cargo terminal is related to optimum position of the cargo transfer equipment to cater for two extreme situations, that is, with the largest vessel in light displacement condition at high water and with the smallest vessel fully laden at low water. The deck elevation should normally be at or above highest high water spring plus half height of an incident wave at the berth location plus a clearance of 1 m.

6.3.8 It is recommended that the minimum total land area behind berths should be as follows:

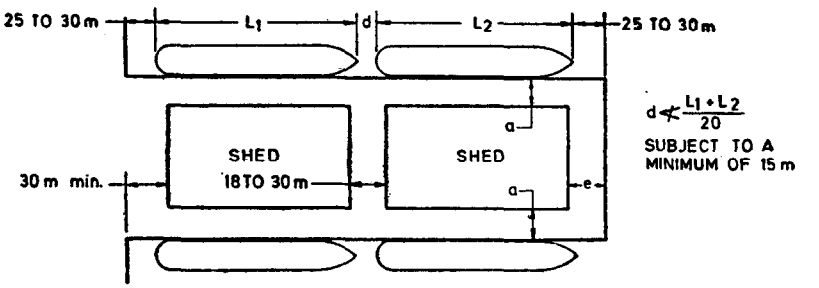
General cargo berths	2·5 to 3·0 ha
Container berths	8 to 12 ha
Bulk cargo berths	Related to the type of cargo to be handled, type of equipment envisaged, capacity of the stockyard, rail and road requirements, etc.

6.3.9 *Crane Track*

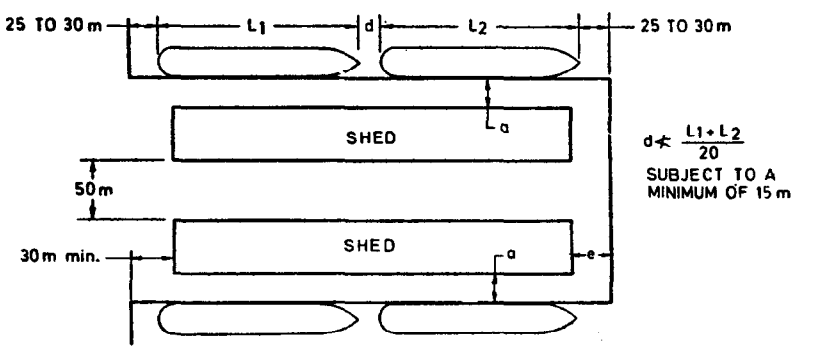
6.3.9.1 *Track gauges* — A track gauge of 6·0 m has been recommended as a standard gauge for the wharf cranes unless otherwise demanded by local considerations.



TYPE I (TWO BERTHS)



TYPE IIA (FOUR BERTHS)



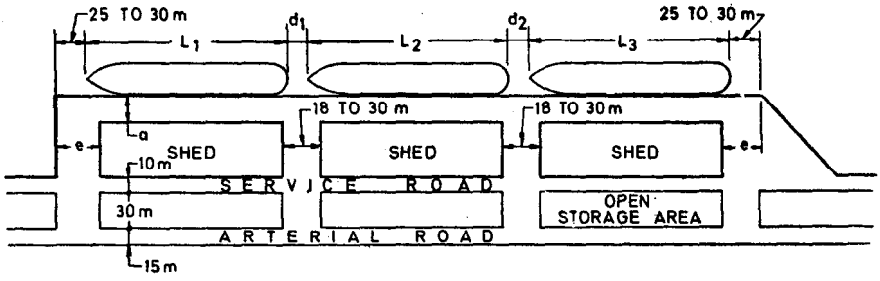
TYPE IIB

9A FINGER PIER BERTHS

a — Width of apron

e — Turning space for trucks, varies between 6 to 15 m inversely with 'a'

FIG. 9. DIMENSIONS FOR GENERAL CARGO BERTHS — *Contd*



$d_1 \not< \frac{L_1 + L_2}{20}$ SUBJECT TO A MINIMUM OF 15 m

$d_2 \not< \frac{L_2 + L_3}{20}$ SUBJECT TO A MINIMUM OF 15 m

TYPE III
9B MARGINAL BERTHS

a — Width of apron

e — Turning space for trucks, varies between 6 to 15 m inversely with 'a'

FIG. 9 DIMENSIONS FOR GENERAL CARGO BERTHS

6.3.9.2 *Clearance from wharf edge* — The outer rail of the crane track shall be laid as far away from the quay edge as possible without reducing the capacity of cranes to handle cargo from vessels at the desired outreach. This is required to guard against damages likely to occur due to vessels colliding with wharf cranes. The maximum distance of the quay edge inclusive of fixed fenders from the outer crane track is recommended as 2·65 m.

6.4 Mooring Facilities — The shape, size and location of mooring devices is dependent on the type of berthing structure, size of vessel to be handled, wind and tidal condition at the berth location.

6.4.1 *Bollards* — For general cargo berth, the spacing of spring line and breast line bollards should be 25 to 30 m along the length of the berth and these should be located approximately 0·15 m behind the cope line of the berthing structure. Larger fittings or corner posts may be installed at the outshore corner of the pier or wharf for handling bow and stern mooring line. Spacing of bollards may be varied to cater for special conditions.

6.4.2 *Cleats* — For handling smaller vessels or harbour crafts, mooring cleats or rings should be installed between mooring bollards along the entire length of the pier or wharf, mooring cleats may be located in line of the bollards and mooring rings approximately 50 cm above the mean high water level.

6.4.3 *Capstans* — These are usually provided to assist the movement of vessels, though entering locks, and passages together with wharping of

vessels, into and out of graving docks and floating docks. Capstans are also provided at offshore berths.

6.4.4 *Mooring Dolphin* — Where the length of the berthing structure is comparatively small, separate mooring dolphines with bollards mounted on top would be necessary for effective handling of bow and stern mooring lines. The number and location of the mooring dolphines should be such that the bow and stern lines from vessels of different sizes can be laid with an angle not steeper than 45° with respect to berthing line in the horizontal plane. Mooring dolphins should be ideally located 30-45 m behind the berthing face wherever possible.

6.4.5 Chains or ladders and staircases suitably recessed into the structure should be provided at suitable intervals along the pier or wharf as a safety measure.

6.5 Utility Services

6.5.1 *Lighting* — Adequate lighting should be provided in this area and average horizontal illuminance of 20 lux is recommeded in the working area while average illuminious of 5 lux is recommended in other areas of apron.

6.5.2 *Water Supply to Ships* — Two water supply points, 50 m on either side of the berth centre line may be provided, each with a minimum capacity of 600 to 900 l/min having a minimum outlet pressure of 175 kN/m² (1·75 kgf/cm²).

6.5.3 *Fuel Supply* — Where demand for bunkers is expected, fuel supply points with a delivery capacity of 100 to 150 tonnes per hour should be provided along side the water supply system except on oil terminals where the bunkering points may be located on the loading/unloading manifold.

6.5.4 The following utility services may also be provided;

a) Adequate shore-to-ship telephonic connection;

b) Access to coastal facilities; and

c) If tankers are likety to visit the port, tank cleaning facilities with facilities for acceptance of oil and water mixtures.

7. STORAGE AREAS AND SHEDS

7.1 Storage Areas

7.1.1 For bulk cargo the area for open storage, where required, should be determined by considering the location of inland transport facilities as well as proximity to the berth.

7.1.2 The minimum open storage area required for supply berth should be one shipload, but where continuous replenishment to the stockpile

cannot be assured, the capacity of the storage area should be calculated on the basis of annual throughput and the rate of supply to storage area and rate of removal from storage area.

7.1.3 Storage of petroleum products should be separated from main port area and be confined within the dykes.

7.2 **Transit Sheds and Warehouses** — The following additional space is required in a transit shed for which provision should be made in the layout:

a) Lock fast room for housing pilferable, valuable and highly dutiable goods for customs inspection and clearance. The enclosure should be made of wells and grills construction;
b) Separate storage compartments for dirty cargo such as paints, lamp black oil, etc;
c) Room for stevodore's gear;
d) Wash room, toilet facility;
e) General office and customs office, normally to be provided at the head end of the shed;
f) Space for shipping clerk and customs inspector; and
g) Telephone booth.

7.2.1 *Dimensions*

7.2.1.1 *Area* — For general cargoes, the gross floor area should be determined on the basis of volume and type of cargo moving through the shed, frequency of ship calling, rate of clearance of cargo from the shed, spaces occupied by aisles and operational staff, etc. For berth handling ships of 10 000 to 15 000 DWTs, the gross floor area of transit sheds is about 7 000 to 9 000 m^2. For larger ships more area may be provided.

7.2.1.2 *Length and size* — Where possible, the length of the transit shed should be out to out length of the fore and aft hatches of the largest design vessel. In multiple berth dock, it would be desirable to provide individual transit shed for each berth. The clear space between two adjacent sheds should be 18 to 30 m for truck access and flexibility in cargo handling (*see* Fig. 9).

7.2.1.3 *Height* — The recommended minimum height inside the transit shed should be 6 m clear. For mobile crane movement inside the shed, a minimum clearance of 7·50 m should be adopted.

7.2.1.4 *Spacing of columns* — Minimum span for shed and internal columns should be 12 m in both directions. Longitudinal spacings of wall columns should not be less than 6 to 8 m depending upon door size.

7.2.1.5 *Doors* — Doors should be planned both in front and back, opposite to each other. In addition, one or two large doors should be

provided at the gable ends for easy access of trucks, cranes, fork lifts, etc. All doors should be provided with locks and bolts which can be operated from inside.

a) *Spacings* — For transit sheds having narrow apron, the spacing of the door should preferably be in each bay but not greater than alternate bay, to minimize lateral movement on the apron.

Where wide aprons are provided, doors should be provided at every second or third bay. Maximum centre to centre distance between two doors should not be greater than 18·50 m.

b) Minimum size of door should be 3·70 × 4·90 m high, desirable size being 5·50 × 6·00 m high.

c) *Type* — Doors may be roller shutter or horizontal sliding suspended from overhead rails type with a safety device to prevent door shutter lifting of accidently.

d) *Wicket doors* — In large doors, especially at the gable ends, a small wicket door should be provided for the access of workmen to avoid opening of the entire door when not in use for cargo transit. The minimum size of a wicket door shall be 1·00 × 2·25 m high.

e) Peepholes covered with mesh (100 mm ϕ).

7.2.1.6 *Floors* — The floor should be provided with slope upwards for cleaning and drainage. The desirable slope should be 1 in 100. For special uses and loading devices, floors may be sloped suitably.

Floors should have smooth even surface, concrete floor should contain a layer of floor hardner or filling to prevent severe wear. Precast and prestressed concrete floor slab may be given 4 cm thick asphaltic concrete wearing coat and finishing smooth. Asphaltic pavements may also be used for flooring of transit sheds.

7.2.1.7 *Loading platform* — The minimum width of the loading platform at the rear and inshore end should be 3·65 m. The height of the platform should not be less than 1 m and not greater than 1·25 m from roadway/top of rail level. Platform should be covered with canopy extending at least 1·50 m beyond the edge of the platform.

7.2.1.8 *Appurtenances*

a) *Ventilators* — Ventilators should be provided in transit sheds. Design based on one-and-half air changes per hour gives desired effect. Ventilators may be round gravity type, the continuous ridge ventilators or forced draft mechanical ventilators.

b) *Lighting* — Adequate provision for natural daylight should be made by providing roof and/or side wall lighting. Artificial light should also be installed to supplement or replace natural light. Average horizontal illuminance recommended is 100 lux.

c) *Protective devices* — All openings, depressed areas and drive ramps should be guarded with concrete curbs, and pipe hand rails to prevent accident.

All internal columns and door jambs should be protected up to a height of 1·5 m by using heavy pipe guard rail, angle iron set in the corner or similar device.

Walls may be protected by using concrete on the lower section. Electrical panels, water and fire piping should be protected by some guide frame.

d) *Windows* — These be suitably provided.

7.2.1.9 *Multistorey transit sheds* — Normally, behind the berth single storey shed is to be preferred where there is no space restriction behind the berth. For restricted areas two-storey sheds may be constructed in which case, separate floors can be used for handling imports and exports advantageously. Transit sheds should not be built more than two storeys high. Where wharf crane is used for handling cargo in and out of the first floor of a two storey shed, a setback or a cantilevered balcony of minimum 3 m width for the first floor measured from the outside face of dock side wall below should be provided for direct unloading on the roof before transit into the upper storey shed.

8. ROADS AND PORT RAILWAYS

8.1 The layout and design of roads and port railways should conform to relevant standards.

8.1.1 *Roads* — The following general considerations are necessary in planning the port road system:

a) The road system in the docks should comprise arterial roads for through traffic and feeder and circulatory roads to the individual berths, depots, yards and other operational points. The arterial roads should be set at the back of the berths and be linked to the public road system through the security gates. Railways crossing the arterial roads should be kept to the minimum.

b) The width of the road should be as large as possible and determined on the basis of expected traffic with provision for future widening. Arterial roads should preferably be 18 m wide, feeder roads 12 m wide and circulatory roads 9 m wide. Adequate camber and super elevation should be provided consistent with the speeds permitted inside the docks.

c) For single lane roads passing lanes should be provided at suitable intervals.

d) The roads should be properly drained.

e) The roads should be properly lit.

f) Loadings, intensity of traffic, location, uses, nature of subgrade, and capital and maintenance costs affect the selection and design of pavement.

g) Ducts or tunnels should be laid across roads for crossing of services.

8.1.2 *Port Railways* — The size and capacity of the port railways system should be consistent with the volume of inward and outward rail traffic expected to use the port. A well laid out system should have the following features:

a) Exchange siding or marshalling yard for exchanging incoming and outgoing trains between main line railways and port railways.

b) Classification yard or sorting siding for breaking up main line trains into trains of wagons in berth, warehouses or for sorting out outgoing wagons into train order for handling over to despatch line.

c) *Sick or Heavy Repair Line* — Where bulk material such as ore, coal, bulk chemicals are unloaded using wagon handling equipment, sick or heavy repair line should be provided for inspection and sorting sick wagons. Generally, a separate shunting neck-off classification yard and connecting despatch line is used for this purpose.

d) Shunting loco sheds and provision of fuelling of port locomotives.

e) Automatic wagon movement and control system for operation of port railways.

8.1.3 *Quay Side Tracks* — These need only be provided if there is sufficient cargo for direct loading and unloading to and from trains. On most quays, two tracks on the quay side and two in the rear of transit shed should be sufficient. One track on each side should be used as a service track connecting the sorting siding. Quay side tracks should be laid with top of rail level flush with squay surface to ensure no obstacle to road vehicles.

9. FUNCTIONAL AND OPERATIONAL BUILDINGS

9.1 In planning the layout of port area, the requirements of the following functional and operational buildings also have to be kept in view. While it is not possible to lay down any standards to cover these buildings, guidelines regarding their functions and possible locations are indicated below.

9.1.1 *Traffic Offices* — Usually there is main office for the staff of the traffic department like wharf superintendent, cash officers, shift staff, etc, and is located near the docks. There are also sub-offices department, ship agents, etc.

9.1.2 *Custom Officer* — Generally there is a main office to accommodate custom inspector and his staff and there are also sub-offices located at berths for accommodating custom appraisers, etc, who have to perform their functions at individual berths whenever ships are there. Usually these sub-offices are located in transit sheds wherever available.

9.1.3 *Deputy Conservator's Office and Signal Tower* — This is normally provided in a multi-storeyed building which is located in such a place commanding a good view of approach channel and entrance. The offices of the deputy port conservator and his staff and staff of P & T Signal and Meteorological Department are accommodated in this building. On the roof of this building signal mast, transmission poles, meteorological instruments, etc, are housed.

9.1.4 *Mooring Master's Office* — This is a small office located near berths to accommodate the offices of mooring master, his staff and stores.

9.1.5 *Dock Master's Office* — This is also a small office located in respective dock areas to accommodate dock master and his staff.

9.1.6 *Sheds for Cargo Handling Equipment* — These are required to house cargo handling equipment like cranes, fork lifts, etc, and they are preferably located between berths.

9.1.7 *Hazardous Cargo Shed* — This shed is required for storing hazardous goods and hence has to be located at a comparatively isolated place.

9.1.8 *Fumigatorium* — This shed is required for fumigating cargoes like cotton bales.

9.1.9 *Illumination Towers* — These are required for illuminating the wharf area and are generally located at the frontage in between berths and at open yards.

9.1.10 *Incinerator* — This is required to dispose off waste matters and is located taking into consideration prevalent wind direction, location of residential buidings, etc.

9.1.11 *Transit Sheds and Warehouses*

9.1.12 *Fire Station*

9.2 In addition, other buildings like power house sub-stations, railway buildings, offices, workshops, dock safety offices, staff and labour amenities like canteen and rest places, stores, etc, are to be provided for. Toilets for shore workers as well as for staff from ships should also be provided. This must be placed within easy access from the ship's gangway.

9.3 Suitable places have to be earmarked in the master plan for buildings to be constructed by other departments/agencies, like buildings for port health officer, ship surveyor, merchant navy club, shipping companies, naval/coast guards.

10. FIRE PROTECTION

10.1 Preventive Measures — The design and layout of operational facilities for the port should be carefully planned. The following considerations are required to reduce potential fire hazards:

a) Pier structures should be separated by adequate open space from adjoining buildings and upland storage areas.

b) Maximum utilization of non-combustable building materials, compartmentalisation of piers and storage structures by fire stops and fire walls.

c) Provision of adequate automatic sprinkler system and/or fire hydrants.

d) Adequate fresh or salt water supply under pressure.

e) Provision of flrst aid fire extinguishing equipment at strategic location.

f) fire alarms at easily accessible locations.

g) Proper maintenance of electric circuits and equipment.

10.1.1 *Non-combustible Construction* — Reinforced concrete bricks, steel-framed with corrugated iron and asbestos cladding offer some degree of fire resistance. To increase the fire resistance, structural steel in storage sheds may be encased with concrete and concerete floor slabs may be made minimum 12 cm thick.

Transit sheds and warehouses may be divided into separate sections by constructing fire wall spaced at 100 m centres or where floor area exceeds 4 000 m^2. In piers, fire stops may be constructed at 50 m centres and fire walls at 150 m centres.

10.1.2 *Automatic Sprinklers, Dry Mains and Fire Hydrants* — At warehouse and storage sheds exceeding 1 000 m^2 floor area automatic sprinklers should be installed to arrest the spread of fire.

Fire hydrants on quay side and yard hydrant should be spaced at approximately 100 m centre in all directions.

10.1.3 *First Aid and Fire Extinguishing Equipment* — The following are the recommended fire extinguishing equipment which should be stored at strategic locations at the pier and in storage shed:

a) *Soda/acid or water type portable extinguisher* — Aggregate capacity 10 l per 200 m^2 of floor area but not less than 20 litre per floor.

b) *Hydrant hose reel* — One 20/25 mm diameter tubing per 400 m^2 or one per floor minimum. A light weight hose cart may be stored in a shed on the open pier and hand driven to hose station, when needed.

c) *Water bucket* — Three numbers per 200 m^2 floor area, but not less than one per floor.

10.1.4 *Fire Alarm* — Fire alarm should be installed in boxes and located on the pier on pedestal and on quay wall at 100 m centres and be connected to overall fire-alarm system of the port.

10.1.5 *Water Supply for Fire Fighting* — As a rough guide watersupply required for combating fire in storage shed is 4 500 l/min for minimum 4 hours for the automatic sprinkler system. The recommended residual pressure at the sprinkler head is 98·00 kN/m^2 (1·00 kgf/cm^2). Where there is no sprinkler system, the minimum requirement of water supply through water hydrant is 9 000 l/min at a residual preasure at the pump hydrant point of 75 kN/m^2 (0·75 kgf/cm^2).

For pier or wharf up to 600 m length, the water supply requirement is 6 000 l/min at a minimum residual pressure of 1 500 g/cm^2 up to a maximum of 12 000 l/min for a multiple berth wharf or pier.

APPENDIX A

(*Clause* 6.3)

DIMENSIONS OF BERTHS

Tonnage	Depth of Water at Berth m	Length of Berth m
a) *Passenger Ships (GRT)*		
500	4·5	65
1 000	5·0	80
2 000	5·0	100
3 000	6·5	115
4 000	7·0	125
5 000	7·5	135
6 000	8·0	145
7 000	8·5	150
8 000	8·5	155
10 000	9·0	170
15 000	9·5	190
20 000	10·0	210
30 000	11·0	240
50 000	11·5	275
80 000	13·0	320

Tonnage	Depth of Water at Berth	Length of Berth
	m	m
b) *Freighter (DWT)*		
700	4·5	60
1 000	5·0	70
2 000	5·5	90
3 000	6·0	105
4 000	7·0	120
5 000	7·5	130
6 000	8·0	140
7 000	8·0	145
8 000	8·5	155
9 000	9·0	160
10 000	9·0	165
12 000	9·5	175
15 000	10·0	185
17 000	10·5	190
20 000	11·0	195
c) *Tankers (DWT)*		
700	4·5	60
1 000	5·0	70
2 000	5·5	85
3 000	6·0	100
4 000	6·5	110
5 000	7·0	120
6 000	7·5	130
8 000	8·0	145
10 000	9·0	165
12 000	9·0	175
15 000	9·5	185
17 000	10·0	195
20 000	10·5	200
30 000	11·0	210
35 000	11·0	220
40 000	12·0	240
45 000	12·0	250
50 000	12·5	255
65 000	14·0	280
85 000	15·0	290
100 000	16·0	315
200 000	17·5	350
300 000	19·0	400

Tonnage	Depth of Water at Berth	Length of Berth
	m	m
d) *Ore Carriers* (*DWT*)		
1 000	7·0	120
6 000	7·5	135
8 000	8·5	150
10 000	9·0	165
12 000	9·5	175
15 000	10·0	185
20 000	10·5	205
25 000	11·0	220
30 000	11·5	230
40 000	12·0	250
50 000	12·5	265
60 000	13·0	275
80 000	13·5	290
e) *Large Fishing Vessels* (*GRT*)		
500	5·0	65
750	5·5	75
1 000	6·0	85
10 000	10·5	175
17 000	13·5	210

BUREAU OF INDIAN STANDARDS

Headquarters :
Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002
Telephones : 331 01 31
331 13 75
371 94 02

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :	***Telephone***
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002	331 6617 335 3841
*Eastern : 1/14 CIT Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054	37 86 62
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 38 43
Southern : C.I.T. Campus, IV Cross Road, MADRAS 600113	235 23 15
†Western : Manakalaya, E9 MIDC, Marol, Andheri (East), BOMBAY 400093	832 92 95
Branch Offices :	
'Pushpak', Nurmohamed Shaikh Marg, Khanpur, AHMADABAD 380001	30 13 48
‡Peenya Industrial Area, 1st Stage, Bangalore-Tumkur Road, BANGALORE 560058	839 49 55
Gangotri Complex, 5th Floor, Bhadbhada Road, T.T. Nagar, BHOPAL 462003	55 40 21
Plot No. 21 Satyanagar, BHUBANESHWAR 751007	40 36 27
Kalaikathir Building, 6/48 Avanashi Road, COIMBATORE 641037	21 01 41
Plot No. 43, Sector 16 A, Mathura Road, FARIDABAD 121001	8-28 88 01
Savitri Complex, 116 G.T. Road, GHAZIABAD 201001	8-71 19 96
53/5 Ward No. 29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003	54 11 37
5-8-56C L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001	20 10 83
R 14, Yudhister Marg, C Scheme, JAIPUR 302005	38 13 74
117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76
Seth Bhawan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road, LUCKNOW 226001	23 89 23
Patliputra Industrial Estate, PATNA 800013	26 23 05
T.C. No. 14/1421, University P.O., Palayam, THIRUVANANTHAPURAM 695034	6 21 17
Inspection Offices (With Sale Point) :	
Pushpanjali, 1st floor, 205-A, West High Court Road, Shankar Nagar Square, NAGPUR 440010	52 51 71
Institution of Engineers (India) Building 1332 Shivaji Nagar, PUNE 411005	32 36 35

* Sales Office is at 5 Chowringhee Approach, P.O. Princep Street, CALCUTTA 700072 — 27 10 85
†Sales Office is at Novelty Chambers, Grant Road, BOMBAY 400007 — 309 65 28
‡Sales Office is at 'F' Block, Unity Building, Narasimharaja Square, BANGALORE 560002 — 222 39 71

Printed at Simco Printing Press, Delhi